From NDE to NDEAA Technologies

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Dr. Yoseph Bar-Cohen is a graduate of the Hebrew University, where he got all his three degrees including Ph.D. in physics. He was the first graduate of the School of Applied Science and Technology, which was opened in the Fall of 1970, where he received extensive Material Science background during his M.Sc. studies. The School of Applied Science offered him the entry to the world of NDE, where in the summer of 1991 he worked as a coop student at the Israel Aircraft Industry (IAI), under the supervision of Mr. Michael Meron. This summer position was the start of Dr. Bar-Cohen carrier in NDE, in which he found great carrier potential since at that time it was based more on the expertise of the operators and was not as well founded science as today. He was offered at IAI an opportunity to conduct his M.Sc. thesis on the topic of NDE of adhesive bonding, which has been of great concern particularly in relation to helicopter blades. His M.Sc. advisor was Prof. S. Shiber, who headed the Materials Science program. After he graduated in 1972, he joined IAI as a Senior NDE Specialist at the Engineering Division of IAI and initiated the in-house R&D and the NDE standards for the company. He established cooperation with such research organizations as Weisman Institute in the area of Holography and with the Technion in the area of NDE of composite. His joint research with Prof. Ori Ishai from the Technion lasted more that 10-years.

FIGURE 1: Dr. Yoseph Bar-Cohen at his NDEAA Lab at the Jet Propulsion Laboratory in Pasadena, CA

Two years after starting to work at IAI and while continuing to work as a full time employee, he begun studying at the Hebrew University towards Ph.D. under the guidance of Prof. Ephraim Harnik. The subject of his thesis was "Direct Ultrasonic Visualization Devices," where he developed an imaging system that takes advantage of the analogy between ultrasound and light. Upon graduating in 1979, Dr. Bar-Cohen received a Postdoc scholarship from the USA National Research Council to work on NDE of composites at the US Air Force Materials Laboratory (AFML) in Dayton, Ohio. In the first month of his arrival (July 1979) he discovered the Polar Backscattering phenomenon and three years later (August 1982) he discovered the

Leaky Lamb Wave phenomenon. These two phenomena have been the subject of research for leading NDE experts worldwide for many years and are continuing to challenge the investigators. A year after arriving to Dayton he was hired by Systems Research Lab (SRL) as the Senior Physicist leading the Air Force in-house NDE contract at AFML.

To fulfil his desire to gain experience in industry he left Dayton in 1983 to Long Beach, California, and begun working at McDonnell Douglas (MDC) as a Principal Specialist. At MDC he established a research and development laboratory and enhanced the practicality of the two ultrasonic phenomena that he discovered earlier. He worked extensively with the University of California at Los Angeles (UCLA), where since 1989 till present, he has the appointment as an Adjunct Professor at the level of full Professor. In 1991, he decided to change affiliation and to join NASA - Jet Propulsion Laboratory (JPL) in Pasadena, California.

Generally, JPL is responsible for the NASA unmanned deep space exploration programs. In recent years, JPL has become increasingly involved with in-situ planetary exploration tasks where miniature, low power, light and inexpensive telerobotic mechanisms are needed. These tasks are conducted at harsh temperature and pressure conditions that are challenging the limits of existing technologies. His initial efforts at JPL were mostly dedicated to NDE, he became the editor of the NASA NDE Working Group Quarterly Newsletter and published the first 13 issues. His expanding beyond NDE started with his co-founding of the NASA Materials & Processes Engineering Working Group, and the co-chairing of the first three annual meetings.. Increasingly he sought broadening his research activities to other areas where his NDE expertise can become an asset and offer added value. He started working on advanced actuators and initiated new concepts for ultrasonic motors, pumps, driller and artificial muscles (Figure 2), for which earned several registered patents. He named his group NDE and Advanced Actuators (NDEAA) Technologies providing multidisciplinary expertise to develop and apply ultrasonics, piezoelectric and electroactive material technology to actuation, robotics, geophysics, medicine and others. He has over 180 publications and a similar number of presentations in national and international conferences. Dr. Bar-Cohen served as the chair and cochair of conferences, track coordinator and session chair for several societies and professional organizations including ASNT, SPIE, MRS, and others.

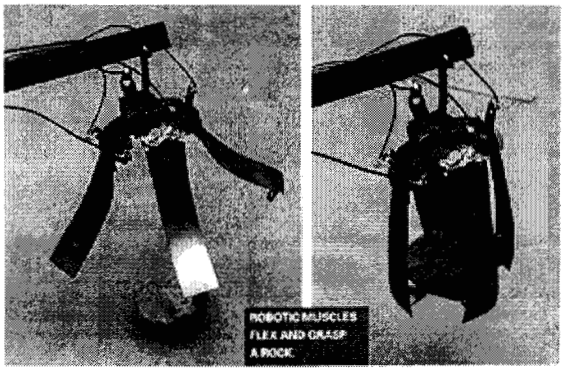

FIGURE 2: 4-finger EAP gripper lifting a rock much like a human hand (Discover, Vol. 19 No. 8 (August 1998), p. 33). EAP is operating similar to human muscles enabling unique mechanisms.

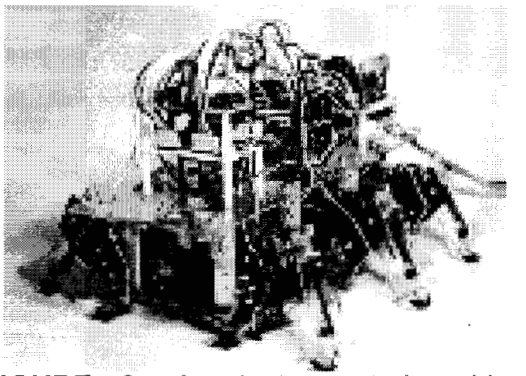

FIGURE 2: An instrumented spider at the University of Tokyo illustrates the potential to NDE in terms of mobile sensors [http://www.leopard.t.u-tokyo.ac.jp/]. If future years, such robots can be developed to inspect interior of engine and other hard to reach areas.

A recent R&D areas that gained him a celebrity status (e.g., interviews with Time Magazine, LA Times, Business Week, Discover Magazine, NBC as well as other news media and radio stations) is his recent work with artificial muscles, related to electroactive polymers (EAP). For many years, EAP received relatively little attention due to the small number of available materials and their limited actuation capability. The recent emergence of EAP materials with large displacement response changed the paradigm of these materials and their potential capability. The main attractive characteristic of EAP is their operational similarity to biological muscles, particularly their resilience and ability to induce large actuation strains. Unique robotic components and miniature devices are currently being explored, where EAP materials serve as actuators to enable new capabilities. In recognition of the need for international cooperation among the developers, users and potential sponsors, Dr. Bar-Cohen organized the first SPIE Conference on March 1-2, 1999, in Newport Beach, California. The conference was the largest ever on EAP, and it marked an important milestone, turning the spotlight onto these emerging materials and their potential. Following this success, MRS conference was initiated to address the fundamental issues related to the material science of EAP. He initiated the WW-EAP newsletter and already published 2 issues to bring the worldwide EAP community even closer. He also established a homepage linking websites of worldwide EAP research and development facilities. Recently, Dr. Bar-Cohen challenged the worldwide community of EAP experts to develop a robotic arm that is actuated by artificial muscles to win a wrestling match with a human opponent (Figure 4). Progress towards this goal will lead to great benefits, particularly in the medical area, including effective prosthetics. Decades from now, EAP may be used to replace damaged human muscles, leading to a "bionic human." A remarkable contribution of the EAP field would be to one day seeing a handicapped person jogging to the grocery store using this technology.

FIGURE 4: A challenge that Dr. Bar-Cohen posed to the worldwide EAP community for the development of artificial muscles

More information covering Dr. Bar-Cohen R&D activity is available on http://ndeaa.jpl.nasa.gov